DECLARATION

I, Dale Robert Hutchinson, c/o MIURA & ASSOCIATES, Nishiwaki Building 4F, 1-4, Kojimachi 4-chome Chiyoda-ku, Tokyo Japan 102-0083, do hereby declare that I am familiar with the English and Japanese Languages and that I believe the annexed is an accurate translation of the certified copy of the Japanese Patent Application No.2001-048045, filed on February 23, 2001.

This 11th day of April 26, 2005

Dale Robert Hutchinson

PATENT OFFICE

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Date of Application: February 23, 2001

Application Number: Patent Application No.2001-048045

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【TITLE OF THE DOCUMENT】 APPLICATION FOR PATENT

【REFERENCE NUMBER】 P4398

【ADDRESSEE】 Commissioner, Patent Office

【INTERNATIONAL PATENT CLASSIFICATION】 G03B

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【INDICATION OF FEE】

【Advance Payment Registration Number】 001971

【Official Fee】 21,000 (yen)

【ATTACHED DOCUMENTS】

【Name of Document】 Specification 1

【Name of Document】 Drawing 1

【Name of Document】 Abstract 1

【Comprehensive Power of Attorney Number 】 0007365

【NEED FOR PROOF】 Necessary

【TITLE OF THE DOCUMENT】 SPECIFICATION

【TITLE OF THE INVENTION】 SURVEILLANCE CAMERA AND PHOTOGRAPHING LENS SYSTEM THEREFOR

【CLAIMS】

1. A surveillance camera system comprising a photographing lens system, and a camera body to which said photographing lens system is detachably attached, said camera body including a color imaging device at which an image formed through said photographing lens system is formed; wherein

aberration of said photographing lens system is corrected so that the difference between the focal point position when an MTF value is maximum at the visible wavelength range of about 400nm through 700nm and the focal point position when an MTF value is maximum at the near-infrared wavelength range of about 700nm through 1000nm is less than or equal to 10μm.

2. The surveillance camera system according to claim 1, wherein one of said photographing lens system and said camera body comprises a switchable near-infrared filter and a switchable transparent flat parallel plate which are selectively positioned in front of the color imaging device; wherein the near-infrared filter is positioned in front of the color imaging device during daylight photography, and the transparent flat parallel plate is positioned in front of the color imaging device during night photography.

3. The surveillance camera system according to claim 2, wherein the product of the refractive index multiplied by the optical thickness of the near-infrared filter and the product of the refractive index multiplied by the optical thickness of the transparent flat parallel plate are the same.

4. The surveillance camera system according to claims 1 or 2, wherein said photographing lens system comprises a plurality of photographing lens systems which are attachable to the same said camera body, wherein chromatic aberration in any one of said photographing lens systems are corrected so that the difference between the focal point position when the MTF value is maximum at the visible wavelength range of about 400nm through 700nm and the focal point position when the MTF value is maximum at the near-infrared wavelength range of about 700nm through 1000nm is less than or equal to 10μm.

5. A photographing lens system for a surveillance camera system, said photographing lens system being detachably attached to a camera body including a color imaging device, wherein an object image is formed on the color imaging device via said photographing lens system;

wherein aberration in said photographing lens system is corrected so that the difference between the focal point position when the MTF value is maximum at the visible wavelength range of about 400nm through 700nm and the focal point position when the MTF value is maximum at the near-infrared wavelength

range of about 700nm through 1000nm is less than or equal to 10μm.

6. The photographing lens system according to claim 5, further comprising a switchable near-infrared filter and a switchable transparent flat parallel plate which are selectively positioned in front of the color imaging device; wherein the near-infrared filter is positioned in front of the color imaging device during daylight photography, and the transparent flat parallel plate is positioned in front of the color imaging device during night photography.

7. The photographing lens system according to claim 6, wherein the product of the refractive index multiplied by the optical thickness of the near-infrared filter and the product of the refractive index multiplied by the optical thickness of the transparent flat parallel plate are the same.

8. The photographing lens system according to claim 5 through 7, wherein said photographing lens system comprises a plurality of photographing lens systems which are attachable to said camera body, wherein chromatic aberration in each said photographing lens system are corrected so that the difference between the focal point position when the MTF value is maximum at the visible wavelength range of about 400nm through 700nm and the focal point position when the MTF value is maximum at the near-infrared wavelength range of about 700nm through 1000nm is less than or equal to 10μm.

【DETAILED DESCRIPTION OF THE INVENTION】

【0001】

【Technical Field】

The present invention relates to a surveillance camera system and a photographing lens system therefor, and in particular, relates to a surveillance camera system (day-and-night surveillance camera system) and a photographing lens system therefor which is useable in a visible wavelength range (400~700 nm) and a near-infrared wavelength range (700~1000 nm).

【0002】

【Prior Art and Problems Thereof】

In this type of day-and-night surveillance camera system, color photography is performed in the daytime by forming a surveillance image from light in the visible light range on a color imaging device (CCD) provided in a camera body, and monochrome photography is performed at night by forming a surveillance image from light in the infrared light range and light in the visible light range, and the surveillance image is displayed on a TV monitor. In this kind of surveillance camera system, an infrared-cut filter is positioned in front of the imaging device (in the camera body or camera lens) in day time photography, and a mechanism for removing the infrared-cut filter from in front of the imaging device is

necessary for night photography.

【0003】

In regard to the photographing lens system, since aberration correction in a conventional photographing lens system is carried out with importance being made on the visible light range, a large focus shift occurs in the infrared light range. Accordingly, in the prior art, in night photography, since the focal point is aligned with the imaging plane of the imaging device at the same time the infrared-cut filter is removed, it is necessary to insert a transparent flat parallel plate having a predetermined thickness different from the thickness of the infrared-cut filter, in order to adjust the optical path length. Note that the transparent flat parallel plate includes a function other than an infrared-cutting effect, for example, a flat parallel plate having a filter function such as visible light cutting effect, ultraviolet ray cutting effect, density adjustment, and color temperature adjustment.

【0004】

In particular, in a photographing lens system, and a surveillance camera system having a camera body and an exchangeable lens for detachably attaching the photographing lens system thereto, the amount of aberrations differ depending on the photographing lens system (exchangeable lens). Accordingly, it is necessary to provide a plurality of infrared-cut filters and transparent flat parallel plates of

different thicknesses in front of the imaging device of the camera body in accordance with the aberrations of the photographing lens system, wherein the filters having differing thicknesses have to be selectively inserted in accordance with the type of exchangeable lens used. As a result, a photographing lens system for a day-and-night surveillance camera system of the prior art requires a selective inserting/removing mechanism for the filters having different thicknesses, which inevitably complicates the construction and control thereof. Alternatively, a limitation is made wherein only a specific combination of lens and camera body are allowed for the photographing lens system for the day-and-night surveillance camera system.

【0005】

【Objective Of The Invention】

An object of the present invention is to provide a surveillance camera system and a photographing lens system therefor wherein high quality photography can be performed in the visible light range and the infrared light range. Another object of the present invention is to provide a surveillance camera system and photographing lens system which does not require a complicated insertion/removing mechanism for a variety of filters.

【0006】

【Summary Of The Invention】

The present invention provides a surveillance camera system including a photographing lens system, and a camera body to which the photographing lens system is detachably attached, the camera body including a color imaging device at which an image formed through the photographing lens system is formed, wherein by improving the photographing lens system itself so as to have optical properties appropriate for the day-and-night surveillance camera system, it is possible for only two simple elements, i.e., a filter or a transparent flat parallel plate, to be selectively inserted in front of the color imaging device within the camera body.

【0007】

In other words, in an embodiment of the surveillance camera system and the photographing lens system of the present invention, wherein chromatic aberration in the photographing lens system is corrected so that the difference between the focal point position when the MTF value is maximum at the visible wavelength range of about 400nm through 700nm and the focal point position when the MTF value is maximum at the near-infrared wavelength range of about 700nm through 1000nm is less than or equal to 10μm.

【0008】

One switchable near-infrared filter and one switchable transparent flat parallel plate can be provided on the photographing lens system or the camera body so as to be

selectively inserted in front of the color imaging device, wherein the near-infrared filter is positioned in front of the color imaging device during daylight photography, and the transparent flat parallel plate is positioned in front of the color imaging device during night photography. Preferably, the product of the refractive index multiplied by the optical thickness of the near-infrared filter and the product of the refractive index multiplied by the optical thickness of the transparent flat parallel plate are the same.

【0009】

The present invention is particularly suitable for a system having a plurality of photographing lens systems which are attachable to the same the camera body. Since aberrations are corrected in both of these photographing lens systems are so that the difference between the focal point position when the MTF value is maximum at the visible wavelength range of about 400nm through 700nm and the focal point position when the MTF value is maximum at the near-infrared wavelength range of about 700nm through 1000nm is one of less than and equal to 10μm, a system can be achieved wherein adjustment is not necessary even if the lens is exchanged.

The present invention provides a surveillance camera system including a photographing lens system, and a camera body to which the photographing lens system is detachably attached, the camera body including a color imaging device at which an

image formed through the photographing lens system is formed, wherein by improving the photographing lens system itself so as to have optical properties appropriate for the day-and-night surveillance camera system, it is possible for only two simple elements, i.e., a filter or a transparent flat parallel plate, to be selectively inserted in front of the color imaging device within the camera body.

【0010】

【DESCRIPTION OF THE PREFERRED EMBODIMENTS】

Figures 1 and 2 show a surveillance camera system according to the present invention. The surveillance camera system includes a vari-focal lens system 10, and a camera body 20 to which the vari-focal lens system 10 is detachably attached. A color imaging device 21, to which an object image passed through the vari-focal lens system 10 is formed, is provided fixed within the camera body 20, and a low-pass filter 22 is positioned in front of the color imaging device 21.

【0011】

An infrared-cut filter 31 and a transparent flat parallel plate 32 are provided within the vari-focal lens system 10 (Figure 1) or within the camera body 20 (Figure 2) so as to be selectively inserted in and retracted from the optical axis. The infrared-cut filter 31 is positioned in front of the color imaging device 21 during daylight photography, and the transparent flat parallel plate 32 is positioned in front of

the color imaging device 21 during night photography. A filter selection movement mechanism for the infrared-cut filter 31 and the transparent flat parallel plate 32 is known in the art, and therefore is not shown in the drawings. The product of the refractive index multiplied by the thickness (optical thickness) of the infrared-cut filter 31 and the product of the refractive index multiplied by the thickness (optical thickness) of the transparent flat parallel plate 32 are the same.

【0012】

The vari-focal lens system 10 corrects aberrations while taking into consideration the spectral sensitivity of the color imaging device 21, the spectral transmittance curve of the infrared-cut filter 31, and the daytime wavelength range and the nighttime wave length range. Figure 3 shows an example of a spectral distribution curve of a light source, wherein reference light source D65 is a daytime representative light source, and reference light source A is a nighttime representative light source. Figure 4 shows relative values of a spectral sensitivity curve of the infrared-cut filter 31 (light receiving element) wherein the maximum relative value is 1.0. Figure 5 shows an example of a spectral transmittance curve of the infrared-cut filter 31.

【0013】

The daytime and nighttime focal point positions are

influenced mostly by chromatic aberration. Figures 6 and 7 show the chromatic aberration characteristics of the vari-focal lens system 10 at the short focal length extremity and the long focal length extremity, respectively, of the present invention with respect to the specific data shown in Table 1. Figures 10 and 11 show a comparative example of chromatic aberration characteristics of a vari-focal lens system at the same short focal length extremity and the long focal length extremity, respectively, of the prior art with respect to specific data shown in Table 2. The lens systems shown in Tables 1 and 2 are both two-lens-group vari-focal lens systems. Surface Nos. 18 and 19 represent the low-pass filter 22. In the tables, F_{NO} designates the F-number, f designates the focal length of the entire lens system, W designates the half angle of view (°), f_B designates the backfocus (the distance between surface No. 19 and the imaging plane), r designates the radius of curvature, d designates the lens thickness or distance between lenses, N_d designates the refractive index of the d-line, and ν designates the Abbe constant.

【0014】

【Table 1】

F_{NO} = 1:1.4~1.9

f = 2.88~5.82

W = 68.9~33.2

f_B = 5.22~9.76

Surf.No.	r	d	N_d	ν
1	26.608	1.000	1.77250	49.6
2	8.327	3.300	-	-
3	25.647	1.000	1.77250	49.6
4	10.447	2.050	-	-
5	102.077	1.000	1.72916	54.7
6	8.710	0.890	-	-
7	10.014	2.670	1.84666	23.8
8	29.920	19.68~5.52	-	-
9	50.000	1.800	1.83481	42.7
10	-26.470	0.120	-	-
11	12.800	2.530	1.62041	60.3
12	-27.500	0.430	-	-
13	-15.780	5.610	1.69895	30.1
14	6.350	3.850	1.49700	81.6
15	-12.450	0.100	-	-
16	37.468	1.500	1.74400	44.8
17	-37.468	0.000	-	-
18	∞	3.500	1.49782	66.8
19	∞	-	-	-

【0015】

【Table 2】

F_{NO} = 1:1.4~1.8

f = 2.86~5.85

W = 69.3~32.9

f_B = 5.21~9.78

Surf.No.	r	d	N_d	ν
1	26.608	1.000	1.77250	49.6
2	8.327	3.300	-	-
3	25.647	1.000	1.77250	49.6
4	10.447	2.050	-	-
5	102.077	1.000	1.72916	54.7
6	8.710	0.890	-	-
7	10.014	2.670	1.84666	23.8
8	29.920	19.81~5.54	-	-
9	53.304	2.000	1.83400	37.2
10	-22.703	0.100	-	-
11	13.250	2.430	1.77250	49.6
12	-70.608	0.460	-	-
13	-19.850	5.360	1.80518	25.4
14	6.892	3.440	1.48749	70.2
15	-13.800	0.100	-	-
16	154.400	1.860	1.89400	37.2
17	-18.700	0.000	-	-
18	∞	3.500	1.49782	66.8
19	∞	-	-	-

【0016】

In the photographing lens system based on the data shown in Table 2 of the prior art, as shown in Figure 10, at the short focal length extremity, chromatic aberration in the range from

436nm through 656nm of the visible wavelength range has been corrected to a small amount, and accordingly, chromatic aberration in the near-infrared range (700nm ~ 1000nm) suddenly increases. Furthermore, as can be understood upon comparing the curve shown in Figure 11, this increase in chromatic aberration changes as the focal length increases. In contrast, the zoom photographing lens 10 based on the data shown in Table 1 of the present invention, as shown in Figure 6, the amount of increase of the chromatic aberration at the near-infrared wavelength range of 700nm through 1000mn with respect to the chromatic aberration at the visible wavelength range of 400nm through 700nm is reduced. Furthermore, as can be understood upon comparing the curve shown in Figure 7 with that of Figure 6, this increase of the chromatic aberration remain at substantially the same level even if the focal length increases.

【0017】

The actual focal point position is influenced by not only chromatic aberration, but also aberration other than chromatic aberration (e.g., spherical aberration), the spectral sensitivity of the color imaging device 21, the spectral transmittance curve of the infrared-cut filter 31, and the daytime and nighttime wavelength ranges. The MTF (modulation transfer function) curve represents the focal point positions which are calculated with consideration of the influence each wavelength has on the focal point positions. In other words,

the axial MTF characteristic value is derived from a combined result of the light source spectral distribution curve shown in Figure 3, the spectral sensitivity curve shown in Figure 4 of the light receiving element, the spectral transmittance curve of the infrared-cut filter 31 shown in Figure 5, and aberrations, especially spherical aberration, of each lens and the above-mentioned chromatic aberration. The focal point positions in the visible wavelength range or the near-infrared wavelength range can be defined as the maximum positions for each MTF characteristic value.

【0018】

Figures 8 and 9 are graphs of the calculated focal-shift amounts at the short focal length extremity and the long focal length extremity, respectively, in the visible light range and near-infrared light range, with respect to the data of Table 1 of the zoom photographing lens and consideration of each characteristic of Figures 3 through 5. Whereas Figures 12 and 13 are graphs of the calculated focal-shift amounts in the visible light range and near-infrared light range, respectively, of the zoom photographing lens with respect to the data of Table 2. In these graphs, the wavelengths are sampled in the visible and near-infrared wavelength ranges and weight is attached in accordance with the amount of influence on the focal point positions.

【0019】

In these graphs, the in-focus position is the focal point position at the highest peak in the MTF curve. In comparison with Figures 12 and 13 of the prior art, in Figures 8 and 9 of the present invention, the difference in the position of the peaks in the visible wavelength range and the near-infrared wavelength range is reduced to 10μm or less. The allowance of 10μm changes in accordance with the lens speed, i.e., F-number, and the size of one pixel of the light receiving element. However, in a commonly used lens having an F-number of 1.4, if the allowance is reduced to 10μm or less, the decrease of the MTF value can be determined as an allowable level from Figures 8 and 9. Namely, in Figures 8 and 9, the calibration on the horizontal axis are in units of 20μm (0.02 mm), however, a shift amount of half a calibration (10μm) around the peak of the MTF curve does not decrease much.

【0020】

In the vari-focal lens system of the present invention, in the embodiment of Figure 1 and in the embodiment of Figure 2, the infrared-cut filter 31 is inserted into the light path in daylight photography, and the transparent flat parallel plate 32 is inserted into the light path in night photography. Since the product of refractive index multiplied by the thickness (optical thickness) of the near-infrared filter and the transparent flat parallel plate are the same, the light path length does not change regardless of whether the infrared-cut

filter 31 or the transparent flat parallel plate 32 is inserted therein, so that a correct focus can be attained at the color imaging device 21.

【0021】

Although the above description is directed to the vari-focal lens system 10 which has a variable focal length, the present invention can be applied to a fixed-focal-length photographing lens system.

【0022】

Although the present invention is described with respect to only one specific embodiment based on Table 1, it is easy for those skilled in the art to design a lens system so as to have the aberration characteristics (MTF characteristics) of Figures 6 through 9. The present invention does not concern the design of the lens system itself, but rather concerns providing a lens system which has the aberration characteristics (MTF characteristics) of Figures 6 through 9 in a day-and-night surveillance camera system.

【0023】

【EFFECTS OF THE INVENTION】

According to the present invention, a surveillance camera system and a photographing optical system therefor wherein high quality photography can be performed in the visible light range and the infrared light range can be achieved.

【BRIEF DESCRIPTION OF THE DRAWINGS】

Figure 1 is a schematic view of an embodiment of a surveillance camera system according to the present invention;

Figure 2 is a schematic view of another embodiment according to the present invention;

Figure 3 is a graph showing a light source spectral distribution curve;

Figure 4 is a graph showing a spectral distribution curve of a light-receiving element;

Figure 5 is a graph shown a spectral transparency distribution curve of an infrared-cut filter;

Figure 6 is a graph of an example of a chromatic aberration correction curve of the zoom photographing lens system of the present invention at the short focal length extremity;

Figure 7 is a graph of an example of a chromatic aberration correction curve of the zoom photographing lens system of the present invention at the long focal length extremity;

Figure 8 shows graphs of an example of an MTF curve of the zoom photographing lens system of the present invention at the short focal length extremity;

Figure 9 shows graphs of an example of an MTF curve of the zoom photographing lens system of the present invention at the long focal length extremity;

Figure 10 is a graph of an example of a chromatic aberration correction curve of the zoom photographing lens

system of the prior art at the short focal length extremity;

Figure 11 is a graph of an example of a chromatic aberration correction curve of the zoom photographing lens system of the prior art at the long focal length extremity;

Figure 12 shows graphs of an example of an MTF curve of the zoom photographing lens system of the prior art at the short focal length extremity, in the visible light range and near-infrared light range, respectively; and

Figure 13 shows graphs of an example of an MTF curve of the zoom photographing lens system of the prior at the long focal length extremity, in the visible light range and near-infrared light range, respectively.

【BRIEF DESCRIPTION OF THE REFERENCE NUMERALS】

10 Vari-focal lens system

20 Camera body

21 Color imaging device

22 Low-pass filter

31 Infrared-cut filter

32 Transparent flat parallel plate

【TITLE OF THE DOCUMENT】 ABSTRACT

【ABSTRACT】

【OBJECTIVE】 An object of the present invention is to provide a surveillance camera system and a photographing lens system therefor wherein high quality photography can be performed in the visible light range and the infrared light range, and wherein quality imaging can be achieved in the visible light range and near-infrared light range.

【CONSTRUCTION】 The photographing lens system itself has been improved so as to have optical properties (the difference between the focal point position when an MTF value is maximum at the visible wavelength range of about 400nm through 700nm and the focal point position when an MTF value is maximum at the near-infrared wavelength range of about 700nm through 1000nm is less than or equal to 10μm) appropriate for a day-and-night surveillance camera system.

【SELECTED FIGURE】 Figure 8